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Orange City, Iowa

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REMEDIAL ACTION WORK PLAN FOR GROUNDWATER REMEDIATION

VOGEL PAINT & WAX CO.
GRANT AVENUE BETWEEN 490TH AND 500TH STREET
MAURICE, IOWA

RAMBOLL

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
BioAug	Bioaugmentation
BioStim	Biostimulation
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
DAP	Diammonium Phosphate
DO	Dissolved Oxygen
EDO	Ethylbenzene/Isopropylbenzene Dioxygenase
gpm	gallons per minute
IDNR	Iowa Department of Natural Resources
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
ORP	Oxidation-Reduction Potential
O_2	Oxygen
PRB	Permeable Reactive Barrier
RAWP	Remedial Action Work Plan
RMO	Ring-hydroxylating toluene monooxygenases
TOD	Toluene/Benzene Dioxygenase
TOL	Xylene/Toluene Monooxygenase
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
µg/kg	micrograms per kilogram
µg/l	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter

1. INTRODUCTION

1.1 Purpose and Scope of Remedial Action Plan

The United States Environmental Protection Agency – Region 7 (USEPA) requested that Vogel Paint and Wax Company (Vogel) provide a plan that further evaluates and mitigates the on-site and off-site groundwater plume. Ramboll U.S. Corporation (Ramboll), on behalf of Vogel, has prepared this Remedial Action Work Plan (RAWP) for the site located on Grant Avenue Between 490th and 500th street in the City of Maurice, Sioux County, Iowa ("the Site"; Figure 1), to address USEPA's request. The RAWP has been designed to reduce impacts by benzene, toluene, ethylbenzene, and xylenes (BTEX) in the groundwater underlying the Site. This report includes a summary of the current remedial efforts, the remedial action objectives (RAOs), and an approach to meet those RAOs.

Based on evaluation of the current remediation being conducted at the site and other potential remedial options, a bioremediation approach is presented in this RAWP to be an effective approach to meet the remedial objectives for the site.

1.2 Site Description and History

The Site is located between 490th Street and 500th Street on Grant Avenue, approximately 2 miles south and 1 mile west of Maurice, Iowa. The area is rural and agricultural, with a few residences nearby and a dairy farm directly west of the Site. The property is roughly 80 acres in total area, but remedial efforts have focused on the 25 acres where paint manufacturing wastes have impacted soil and groundwater. The manufacturing wastes included paint sludge, solvents, and resins containing lead, cadmium, chromium, mercury, toluene, xylenes, and mineral spirits (grade naphtha). Disposal activities occurred from 1971 to 1979 in the former sand and gravel pit, a 2-acre area of the property in roughly the center of the Site (Figure 2).

In 1984, the Site was preliminarily added to the Superfund National Priority Listing (NPL) prior to being formally placed on the NPL two years later in 1986. Based on the 1984 NPL evaluation, approximately 43,000 gallons of volatile organic compounds (VOCs) and 6,000 pounds of metals were estimated to be in the subsurface. This estimation was later revised to approximately 80,000 to 150,000 gallons of free product present in the subsurface. As a result, immediate action was taken in 1984 through the installation of a clay cap to reduce volatilization. Site investigation activities were initiated in 1986 and led to the development of a cleanup plan in 1989, described in the next section. To date an estimated 143,000 gallons of product have been removed or remediated from the various soil and groundwater remediation activities conducted on the Site.

1.3 Remedial Activities

The cleanup plan was developed in 1989 and remediation activities were initiated in 1991. Modifications to the remediation plan were implemented in 1994 and 2000. Impacted soil and groundwater have undergone remedial activities since 1991 under the supervision of Iowa Department of Natural Resources (IDNR).

The soil remediation included excavation and off-site disposal, on-site land farming, and the stabilization of metal-impacted soil. Since 1991, the following soil remediation activities have been conducted and completed:

- Soil excavation was conducted down to groundwater in the former disposal trench area in 1991.
- Approximately 65,000 cubic yards of contaminated soil was bioremediated between 1991 and 1999. Treatment of this soil resulted in the removal of an estimated 71,000 gallons of free product.
- Approximately 12,000 gallons of paint sludge and liquid wastes and 3,500 cubic yards of solid (drums and other solid materials) wastes were segregated from the initial soil excavation activities, and these materials were disposed at appropriate off-site disposal facilities.
- During 2000-2001, deeper soil was excavated and repositioned in bio-treatment cells constructed with soil vapor extraction/bioventing piping to treat free product hung up in soil just above the water table, an estimated 31,000 gallons of free product were removed.
- Soil with elevated lead concentrations was stabilized with lime and buried at least 5 feet (ft) above groundwater and 5 ft below surface in 1999.

Groundwater remedial activities included pump-and-treat and free product recovery via groundwater extraction and bailing. Since 1991, the following groundwater remediation activities have been conducted:

- Groundwater extraction from 5 extraction wells was initiated in 1991. Extracted groundwater was treated via air stripper and discharged overland to an infiltration basin located up gradient of the original disposal cell. Extraction from two of these wells was discontinued in 1993 due to low contaminant concentrations.
- Two of the above 5 wells were equipped with free-product recovery pumps, and free product was bailed from 2 other monitoring wells. A total of 16,000 gallons of free product were removed and disposed off-site from 1991 through 2005. A total of 280 million gallons of groundwater were extracted and treated between 1991 and 2005, resulting in an additional estimated removal of 12,800 gallons of dissolved-phase contaminants.
- Groundwater pump-and-treat was ceased in 2002, as approved by IDNR, due to reduction of free product. The remediation system was re-started in 2003 to prevent off-site migration of contaminants and was shut down in early 2005 as a result of stable and declining contaminant concentrations in the southern monitoring wells.
- The groundwater extraction and treatment system was reactivated and used for irrigation purposes in 2008-2009 for establishment of trees for phytoremediation in the former source area. In 2007, one acre of trees was planted and in 2008, an additional 2.5 acres of trees were planted in the former source area to enhance groundwater remediation through phytoremediation. An estimated removal of 127 gallons of dissolved-phase contaminants resulted from groundwater extraction and treatment associated with the irrigation activities.
- The remediation system was re-started in April 2016 with one extraction well, Well RW104. During 2016 and 2017, 4.1 million gallons of groundwater were extracted and treated from Well RW104, resulting in an additional estimated removal of 195 gallons dissolved-phase contaminants.

- An extraction pump was placed in Well MW-4R in December 2005 due to continued residual free product measured in that well. A total of 36 gallons of free product were removed from 2005 until 2011, when the pump was removed due to limited product thickness in the well. Hand bailing of product has been performed since late 2011. An additional 12-gallons of free product has been removed from Well MW-4R from bailing activities. A total of 48 gallons of free product has been removed from Well MW-4R from both pumping and bailing activities conducted between 2005 and 2017.
- An estimated total of 143,175 gallons of free product has been removed from the site through direct excavation and off-site disposal, soil remediation, free product recovery, and groundwater extraction and treatment of dissolved-phase contaminant mass.

1.4 Dissolved-Phase Contaminant Groundwater Plume

Groundwater monitoring reports are published annually and five-year reviews have been published since 1994, with the most recent report being published in September 2014. For purposes of this RAWP, current groundwater conditions were based on the groundwater results from the annual sampling conducted in November 2017 and presented in the 2017 Annual Monitoring Report (GeoTek), Groundwater is currently monitored for BTEX compounds, as their concentrations still exceed their respective Federal drinking water maximum contaminant levels (MCLs) (Figures 3 to 6). Of the BTEX constituents, the ethylbenzene/xylene plume is the largest, at approximately 1,700 feet in length and 100 to 250 feet wide.

Overall, the plume has been relatively stable over the last five years, although contaminant concentrations have been shown to fluctuate with water levels. In particular, contaminant concentrations in monitoring wells located downgradient of the source area appear to be influenced to a large degree by changes in groundwater elevations.

Select groundwater wells are also analyzed for metals on an annual basis. As of 2017, the most recent reporting, metal concentrations were non-detect (ND) or below MCL. This has been a consistent trend in Well GMW-13 located in the middle of the area where soil with elevated lead was stabilized with lime and buried at least 5 ft. above groundwater and 5 ft below ground surface in 1999. In other selected wells that are still being monitored for metals, the reported concentrations have been ND or below MCLs since at least 2015.

1.5 Site Geology and Hydrogeology

The Site is in a rural area on the uplands of the West Branch of the Floyd River. A surficial sand and gravel aquifer and Dakota sandstone bedrock aquifer underlie the Site. Surface soil consist of a 5 to 17-foot layer of clayey silt loess. Two surficial water-bearing zones underlie the site, an "upper sand unit" and a "lower sand and gravel unit." These two water-bearing zones appear to join under the former waste disposal area. North of that area, the units seem to combine into the alluvial aquifer associated with the West Branch of the Floyd River that runs through the northern section of the Site, and south of that area both units exist separately (HDR 1989).

The upper sand thickness ranges from 1 to 10 feet. Glacial till separates the upper sand unit from the lower sand unit. The separating glacial till ranges in thickness from 17 to 20 feet. The lower sand and gravel unit ranges in thickness from 7 to 15 feet. A second glacial till unit acts as it lower confining unit.

Depth to groundwater ranges from 7 feet below ground surface (bgs) at the north end of the Site to between 25 and 33 feet bgs in the main portion of the property. Depth to water at downgradient off-site wells ranges from 23 to 43 feet bgs. Groundwater flow is generally south to south-southeast (Figure 7), with an average gradient of 0.0024 vertical feet change per linear foot (ft/ft) from the source area to the downgradient off-site wells.

2. REMEDIAL ACTION OBJECTIVES AND GOALS

Remedial action objectives (RAOs) are qualitative statements that identify the scope of remediation necessary to protect human health and the environment. The Site RAOs serve as the foundation for developing quantitative remediation goals to address BTEX compounds in groundwater.

The goal of the remedial design presented herein is to provide a strategy to address the elevated concentrations of BTEX detected in the groundwater beneath the Site and reduce concentrations to below MCLs or standards set by the IDNR.

The following RAOs have been developed to achieve the remedial goals:

1. Offer a remedial alternative to address the entirety of the BTEX plume in the groundwater at the Site,
2. Accelerate the timeframe to closure,
3. Continue and modify the groundwater monitoring program to evaluate the effectiveness of the remedial design.

The criteria used to evaluate when the RAOs have been met (i.e., clean-up has been completed) will be a combination of contaminant concentrations and performance-based criteria, including:

- Mass reduction and reduction rates;
- Reduction of dissolved phase concentrations reduction towards remedial goals;
- Removal of residual free product in the immediate vicinity of Well MW-4R;
- Point of diminishing return (i.e., asymptotic conditions and remediation effort and cost exceed the benefits of treatment);
- Application of risk-based corrective action (RBCA) process to establish alternative action levels for groundwater;
- Modifications under the execution of the environmental covenant.

Based on a consideration of current site conditions and evaluation of potentially applicable remedial technologies, a bioremediation approach was selected to meet the RAOs and goals.

3. REMEDIAL APPROACH

For purposes of developing a remedial approach for the groundwater plume, the plume was divided into three areas: the source area, on-site downgradient area, and the off-site area. Remedial options utilizing in-situ technologies were evaluated for each of the plume areas. These remedial technologies were evaluated for feasibility, cost benefit, and projected timeframe to reach the existing cleanup goals.

Ramboll conducted limited groundwater sampling and analysis to better understand current groundwater conditions for application of in situ remedial methods. Results from this sampling efforts is presented in Section 3.1. Based on the Site information and results of recent sampling conducted by Ramboll, various remedial options are presented below.

3.1 Additional Groundwater Sampling and Analysis

Ramboll (with assistance from GeoTek) collected groundwater samples from Wells GMW-14 (source area), TC-6D (on-site downgradient) and GMW-7R (downgradient property boundary) on December 19, 2017. The groundwater samples were analysed for following:

Constituent	Method Number
Ammonia (as N)	350.1
Total Kjeldahl Nitrogen	351.2
Orthophosphate	365.3
Total Phosphorous	365.3
Sulfate	300.0
Total Sulfide	SM 4500
Total Organic Carbon	SM 5310C
QuantArray®- Petro	NA

These constituents were selected to quantify conditions in the water-bearing zone for bioremediation options and for other in situ remedial options.

3.1.1 Results Summary

The general chemistry results are presented in Table 1. The QuantArray®- Petro analysis is a genetic analysis used to quantify specific microorganisms and functional genes to evaluate aerobic and anaerobic biodegradation of BTEX and MTBE, naphthalene and polynuclear aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH). Results from the QuantArray®- Petro analysis for is summarized in Table 2.

- Sulfate concentrations ranged from 1.1 to 39 mg/l; however, sulfide was not detected in the groundwater samples, indicating that sulfate-reducing conditions are not significant in the Site groundwater tested. This result indicates that biodegradation is most likely not occurring through sulfate-reducing processes.
- Total organic carbon (TOC) results are consistent with the reported BTEX concentrations measured in each well sampled, which indicate that the water-bearing zone has very low

native TOC. Native TOC concentration is important in evaluation of remedial technologies. High concentrations TOC will consume injected oxidants, which will result in the need to inject additional materials to overcome natural oxygen consuming conditions.

- Total Kjeldahl Nitrogen (TKN; i.e., total organic nitrogen and ammonia) and ammonia concentrations are low and indicate that the nutrient nitrogen is probably limiting microbial growth in the downgradient areas. Although TKN concentration is higher in Well GMW-14 located in the former source area, it is still at a concentration that is limiting microbial growth.
- Phosphorus is an essential nutrient for microbial growth, and total phosphorus ranges from 0,06 – 0.088 mg/l and ortho-phosphate was non-detect (<0.05 mg/l). These are low concentrations and are most likely limiting microbial growth.
- Eubacteria (often referred to as the "true bacteria") concentrations were similar in the groundwater samples collected from the three subject wells, all greater than 1.5E+06 cells per milliliter (ml), which is in a range typical of groundwater samples. These results indicate that there is a native bacterial population that can be stimulated to promote biodegradation.
- Gene analysis for presence of genes associated with the aerobic biodegradation of BTEX is presented in Table 2 and summarized herein:
  - Samples collected from all three wells indicate that there are significant concentrations of toluene/benzene dioxygenase (TOD) and xylene/toluene monooxygenase (TOL) genes. These genes are both important to the aerobic biodegradation of BTEX compounds, and these results demonstrate the potential for aerobic biodegradation of the site contaminants.
  - Elevated concentrations of the ethylbenzene/isopropylbenzene dioxygenase (EDO) gene was observed in the groundwater sample collected from Well GMW-14, which would support ethylbenzene biodegradation. These results indicate that even though there are elevated concentrations of toluene, ethylbenzene, and xylenes in the source area, there are significant concentrations of the key enzymes responsible for the biodegradation of BTEX in groundwater.
  - Ring-hydroxylating toluene monooxygenases (RMO) were not detected in site groundwater, indicating that bio-augmentation (introduction of bacterial cultures) may substantially enhance biodegradation of BTEX in some areas of the on-site groundwater.
- The groundwater sampled contains very low or non-detectable concentrations of anaerobic genes responsible for BTEX biodegradation, presented in Table 2. These results confirm that only limited to no biodegradation appears to be occurring under anaerobic conditions within the plume.

3.2 Remediation of Source Area

3.2.1 Current Conditions

Current remediation in the source area of the site relies on hydraulic influence from one groundwater extraction wells located downgradient of the source area. Concentrations have remained elevated in the source areas wells. In addition, monitored natural attenuation

(MNA), parameters in the source area wells indicate anaerobic conditions (low dissolved oxygen) along with low nitrogen and phosphorus levels (which represent nutrients required for microbial growth) indicated that biodegradation in this portion of the plume most likely has stalled or is occurring at a very low rate under anaerobic biodegradation conditions.

3.2.2 Bioremediation

Bioremediation is the use of microbial agents such as bacteria for the biodegradation of contaminants. Bioremediation may be implemented in a variety of forms: MNA, by stimulating the indigenous microbial community through the addition of nutrients (biostimulation), through the addition of exogenous microbes (bioaugmentation), or by a combination of methods. Bioremediation was considered in the treatment area described in Section 3.2.1, the roughly 20,000 square-foot former treatment area. In general, selecting the appropriate method of bioremediation is a function of several criteria: water quality parameters such as pH and DO, the abundance of contaminant-degrading microbes, the bioavailability of the contaminants, and the availability of nutrients required for microbial growth. In December 2017, Ramboll conducted a bioremediation feasibility study on wells in the three plume areas and determined conditions in the water-bearing zone are conducive to bioremediation, though the addition of oxygen and nutrient amendments, as well as potentially microbial augmentation, are likely required.

For this remedial design, a slow-release oxygen product (calcium peroxide) will be applied to the treatment area in order to create aerobic conditions and allow for the bio-stimulation of existing bacteria in the water-bearing zone to degrade the BTEX compounds. Exact injection volumes, additional amendments or cultures, and the injection design and spacing will be determined by a field-study, discussed more in Section 4.1. Overall, bioremediation is advantageous from a cost and time perspective with the additional benefit of injecting less material (volume) into the subsurface than with an ISCO treatment.

3.3 Remediation of Downgradient and Off-Site Portion of the Plume

3.3.1 Monitored Natural Attenuation

Unlike the source area, where anaerobic conditions are stalling natural attenuation, portions of the downgradient and off-site plume have sufficient levels of DO for attenuation to occur. Based on Ramboll's recent sampling, there are also areas within the plume where BTEX-degrading genes were observed. Given a long-enough time scale, natural attenuation has the potential to remediate the downgradient and off-site areas of the plume; however, to expedite the remediation process, these natural processes will be enhanced with bioremediation methods.

3.3.2 Bioremediation

Injections for implementing biostimulation (and potentially bioaugmentation) may be applied in a grid application or through strategically-placed injections. The strategically-placed injections will be placed in a line across the width of the plume, creating a permeable reactive barrier (PRB), and allowing for the injection of materials generally across the plume. Based on the plume size, strategically-placed injections provide a better option. This allows for groundwater to flow through the zone of injected material and degrade the BTEX contaminants as it passes through the reactive bioremediation zone (i.e., the PRB). Close-spaced treatment zones will be positioned near and within the off-site downgradient portion of the plume to aid in accelerating the remediation in the off-site portion of the plume. Farther-spaced treatment zones will be located within the middle portion of the on-site plume (down-gradient of the former source area).

In addition, to provide longer term control of possible off-site migration of residual contaminant concentrations, the application of a sorption-based technology will be added to the treatment barrier zone along the downgradient property boundary. The sorption material is a liquid activated carbon (PlumeStop®) developed by Regenesis® Remediation Solutions and Products (Regenesis). This is a fast-acting, sorption-based technology that captures and concentrates dissolved-phase contaminants. Once the contaminants are absorbed onto the injected matrix, biodegradation of the contaminants occur at an accelerated rate. The sorption material also persists in the subsurface for decades, allowing for continued degradation of contaminants and control of contaminant migration over the life of project. This material, coupled with oxygen-releasing compound, supports enhanced aerobic biodegradation over an extended period of time.

4. PRELIMINARY DESIGN CRITERIA AND RATIONALE

Based on the remedial evaluation, bioremediation will be implemented in all three plume zones, with the source area receiving gridded injection and the downgradient and off-site area having strategically-placed injections to form PRBs (Figure 8). This section presents the preliminary design criteria in which the conceptual design is contingent upon.

4.1 Bio-Trap® Units

A Bio-Trap® study will be conducted to determine the in-situ bioremediation timeframes and treatment designs for the contaminants and area. The study will be conducted in partnership with Microbial Insights, Inc. (Microbial Insights), an environmental biotechnology company located in Rockford, Tennessee. In general, a Bio-Trap® study measures the bacteria population over a period of time under specified conditions, as listed below. This will provide key information for establishing the bioremediation design in each area of the plume. Results of the Bio-Trap® study will be used to determine the need for and quantity/dosing of nutrients along with possible bio-augmentation in each application area (grid design in source area and PRBs in remaining portion of the plume).

Ramboll will conduct a Bio-Trap® study by placing Bio-Traps® in the same three selected wells that Ramboll sampled on December 19, 2017 (Wells GMW-14, GMW-7R, and TC-6D), as these wells represent the three areas of the plume. At each of the three monitoring wells, four Bio-Trap® units (one control, two biostimulation, and one bioaugmentation) will be vertically installed within the well screen interval. The biostimulation, or BioStim, unit is a Bio-Trap® unit with a substrate amendment (e.g., oxygen-based or nutrient-based). The oxygen-based amendment will be EOx™, a time-release calcium peroxide (CaO_2) that accelerates aerobic degradation, developed and supplied by EOS Remediation (EOS). The nutrient-based amendment will be Diammonium Phosphate (DAP), which is a soluble micro-nutrient that provides nitrogen and phosphorus for microbial growth. The bioaugmentation, or BioAug, unit is a Bio-trap® unit with Bio-Sep® beads that are pre-inoculated with a bacterial cultural (BAC-TPH) and a substrate amendment, also provided by EOS. The Bio-Trap® control unit, which contains no amendments, will be installed at the top of the unit, approximately 3 to 5 feet above the BioStim and BioAug units. Baffles are used to physically isolate each treatment unit to eliminate vertical transport or "cross-talk". An illustrated schematic of a typical Bio-Trap® unit is included in Figure 9 and details of the units for in-well deployment are summarized below:

Bio-Trap® Unit	Amendment	
Unit 1- Control	Oxygen Amendment	None
	Nutrient Amendment	None
	Bacterial Culture	None
Unit 2- BioStim	Oxygen Amendment	EOx™
	Nutrient Amendment	None
	Bacterial Culture	None

Bio-Trap® Unit	Amendment	
Unit 3-BioStim	Oxygen Amendment	EOx™
	Nutrient Amendment	DAP
	Bacterial Culture	None
Unit 4- BioAug	Oxygen Amendment	EOx™
	Nutrient Amendment	DAP
	Bacterial Culture	BAC-TPH

After retrieval, Bio-Trap® units will be sent to Microbial Insights in Tennessee for chemical and microbial analysis. Based on the results from the Bio-Trap® study, the details for the bioremediation design will be determined. For instance, the Bio-Trap® study may indicate that the biodegradation of the off-site area of the plume would be accelerated by the addition of oxygen, while the downgradient area needs oxygen and nutrient amendments, and the source area needs oxygen, nutrient, and bacterial amendment.

4.2 Bioremediation of Source Area

A slow-release oxygen product (calcium peroxide) will be injected in the source area to create aerobic conditions. Nutrient amendments or bacterial amendments may also be injected, based on the results of the Bio-Trap® study discussed previously. The proposed injection points are tied both to the hydrogeology of the Site and the volume of material to be injected. Injections will be applied in a grid application over an approximate 20,000 square foot-area. A radius of influence of 15-feet is estimated at each injection point for a total of 84 injection points (Figure 8).

4.3 Bioremediation of Downgradient and Off-site Portion of the Plume

As in the source zone, amendments determined by the Bio-Trap® study will be injected into the groundwater. Unlike the remediation in the source area, the downgradient and off-site portion of the plume will receive strategically-placed injections, creating PRBs. Four total PRBs will be installed, two in the downgradient on-site area and two in the off-site area. In the downgradient on-site area of the plume, two PRBs will be formed with approximately 35 injections spaced 15 feet apart, creating one PRB 220 feet in width near Well MW-4R and one PRB 300 feet in width near Wells GMW-16 and GMW-15 (Figure 8). In the off-site area of the plume, two PRBs will be formed with approximately 15 injection points spaced 15 feet apart, creating one PRB 80 feet in width near Well GMW-22 and one PRB 150 feet in width along the property line. In addition, PlumeStop® will be simultaneously injected within the treatment barrier zone along the downgradient property boundary (the 150-foot PRB) in order to accelerate the remediation and prevent further plume migration.

4.4 Removal of Residual Free Product

Only one well (MW-4R) contains free product. During 2017, free product thickness was measured between 0.3 feet and 2.65 feet. The free product is manually bailed from Well MW-4R on a periodic basis as product accumulates in the well. A total of 3.35 gallons of product was removed from Well MW-4R.

To address residual free product present, additional characterization will be conducted to delineate the lateral extent of free product in the immediate vicinity of Well MW-4R. Temporary well casings will be placed in up to ten boreholes completed into the water-bearing zone and to allow groundwater and possible free product to accumulate in the temporary well casings (Figure 10). The thickness of the free product will be measured in each temporary well casing, where present. Based on the results from the temporary boreholes, up to four groundwater extraction wells will be installed to both monitor the thickness of the free product and to further extract the free product through periodic bailing of the wells, as currently being conducted at Well MW-4R.

In situ treatment options for remaining residual free product may be considered at a later time depending on the success of the expanded extraction of residual free product in the immediate vicinity of Well MW-4R.

5. REPORTING AND SCHEDULE

5.1 Groundwater Monitoring

Existing groundwater monitoring wells are currently sampled on a semi-annual basis and for BTEX compounds and MNA parameters. In addition to the existing sampling program, Fourteen selected wells located within the plume area will be sampled on a quarterly basis to further monitor BTEX concentrations along with DO, ORP and pH. All remediation and groundwater monitoring data will be presented in semi-annual monitoring and progress reports.

Groundwater monitoring is projected to last 3 to 6 years following the initiation of remedial alternatives. Groundwater monitoring will continue for 1-year following completion of remediation (meeting remedial goals/groundwater cleanup levels) to confirm concentrations remain below Site-specific cleanup levels and no concentration rebound occurs.

5.2 Schedule

Summary Schedule		
Task No.	**Task Description**	**Estimated Duration (Sequential)**
1	**Bio-Trap® Study and Evaluation**	**10 weeks**
	Bio-Trap Design and Order	4 weeks
	Bio-Trap® Deployment	6 weeks
2	**Remedial Design Work Plan**	**8 weeks**
	Evaluate Bio-Trap® Data	2 weeks
	Amend Remedial Work Plan	6 weeks
3	**Remedial Implementation**	**12 weeks**
	Prefield coordination,	4 weeks
	Residual Free Product Characterization	2 weeks
	Amendment (oxygen, nutrient, and/or culture) Injection	3-4 weeks
	PlumeStop® Injection	1-2 weeks
4	**Initial Post-Injection Monitoring Program**	**10-12 weeks**
Total Estimated Duration		**40-42 weeks**

6. REFERENCES

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TABLES

Table 1. Summary of Groundwater General Chemistry Data
Vogel Paint and Wax Co.
Maurice, Iowa

Well ID	Ammonia	TKN	OrthoP	Total phosphate	Sulfate	Total Sulfide	TOC
	Concentrations (milligrams per liter, mg/l)						
GMW-14	**0.5**	**2.0**	<0.05	**0.06**	**33**	<0.05	**130**
TC-6D	<0.2	0.22	<0.05	**0.088**	**1.1**	<0.05	**18**
GMW-7R	**0.23**	**0.24**	<0.05	**0.087**	**39**	<0.05	**3.1**

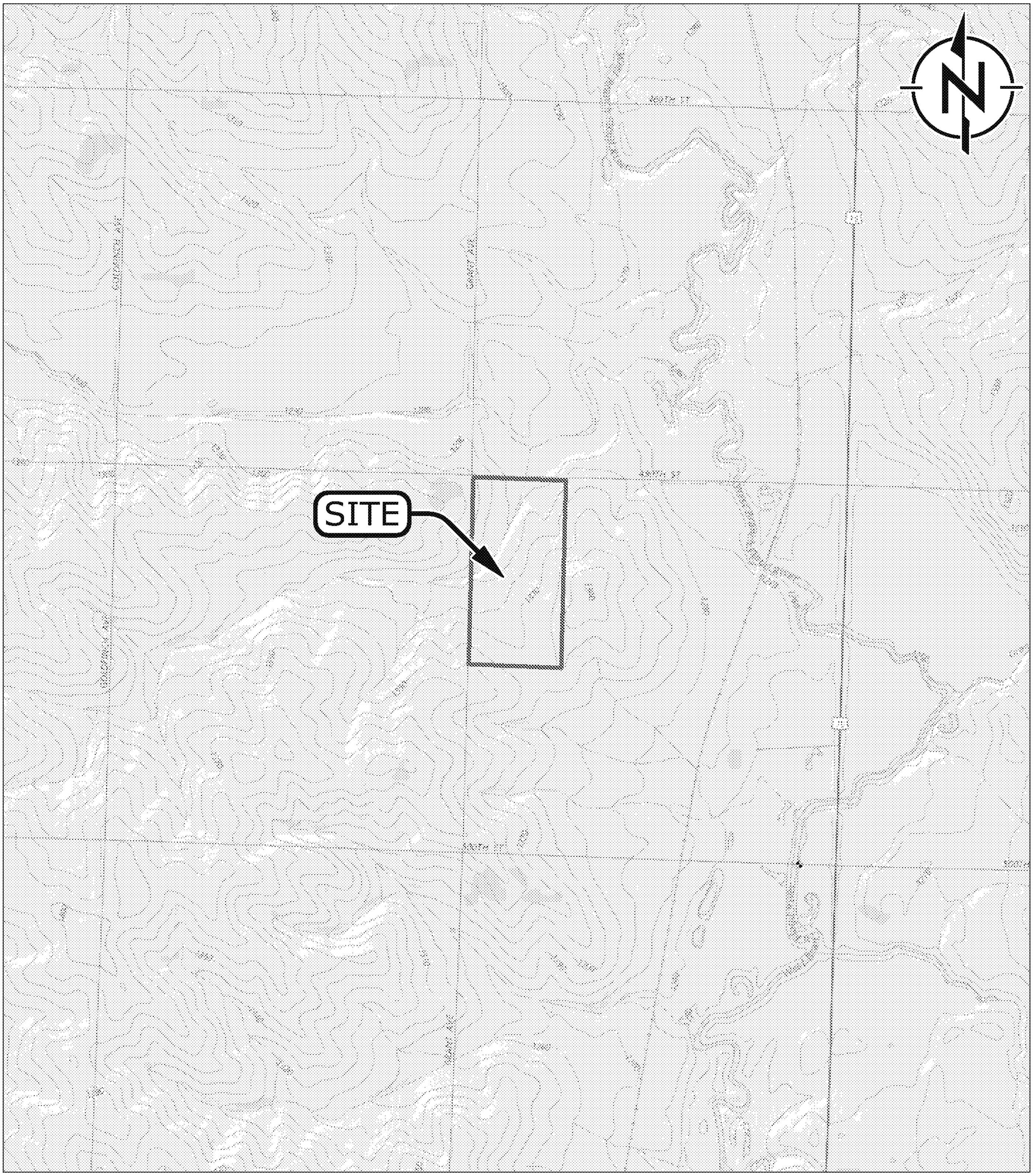
Notes:
OrthoP - Orthophosphate
TKN - Total Kjeldahl Nitrogen
TOC - Total Organic Carbon

Table 2. Summary of QuantArray®- Petro Analysis
Vogel Paint
Maurice, Iowa

Sample Name	GMW-14	TC-6D	GMW-7R
	cells/ml		
Aerobic BTEX and MTBE			
Toluene/Benzene Dioxygenase (TOD)	**7.66E+03**	<4.90E+00	**2.40E+03**
Phenol Hydroxylase (PHE)	**5.55E+01**	**9.90E+00**	**3.00E+00 (J)**
Toluene 2 Monooxygenase/Phenol Hydroxylase (RDEG)	<2.01E+01	<4.90E+00	<5.00E+00
Toluene Ring Hydroxylating Monooxygenases (RMO)	<2.01E+01	<4.90E+00	<5.00E+00
Xylene/Toluene Monooxygenase (TOL)	**9.16E+04**	**2.09E+02**	**1.96E+03**
Ethylbenzene/Isopropylbenzene Dioxygenase (EDO)	**9.22E+03**	<4.90E+00	**2.99E+01**
Biphenyl/Isopropylbenzene Dioxygenase (BPH4)	<2.01E+01	<4.90E+00	<5.00E+00
Methylibium petroleiphilum PM1 (PM1)	<2.01E+01	<4.90E+00	**2.08E+02**
TBA Monooxygenase (TBA)	<2.01E+01	<4.90E+00	**1.00E+00 (J)**
Anaerobic BTEX			
Benzoyl Coenzyme A Reductase (BCR)	<2.01E+01	**9.00E-01 (J)**	<5.00E+00
Benzylsuccinate synthase (BSS)	<2.01E+01	**3.03E+01**	<5.00E+00
Benzene Carboxylase (ABC)	<2.01E+01	<4.90E+00	<5.00E+00

Notes:
J - Estimated value
ml - milliliters

FIGURES



Legend

Approximate Site Boundary

0 0.5 1

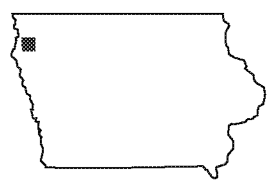
Scale in Miles

0 2,000 4,000

Scale in Feet

NOTES:
CONTOUR INTERVAL 20 FEET

SOURCE:
The National Map, 2018.
Map Scale: 1:24,000 Spatial Reference: NAD 1983 StatePlane Iowa North FIPS 1401 Feet; Map Center: 96°11'32"W 42°56'3"N



KEY MAP

RAMBOLL

Site Location Map
Vogel Paint Waste Site
Maurice, Iowa 51036

FIGURE
1

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PROJECT: 1690001847-004

Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure1_SiteMap_2018-07-23.mxd

Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure2_SiteLayout_2018-07-23.mxd

RAMBOLL	**Site Layout** Vogel Paint Waste Site Maurice, Iowa	FIGURE **2**
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Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure3_PlumeMap_Benzene_2018-07-30.mxd

RAMBOLL	**Benzene Plume Map - December 2017** Vogel Paint Waste Site Maurice, Iowa	FIGURE **3**
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Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure4_PlumeMap_Toluene_2018-07-30.mxd

RAMBOLL

Toluene Plume Map - December 2017
Vogel Paint Waste Site
Maurice, Iowa

FIGURE
4

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Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure5_PlumeMap_Ethylbenzene_2018-07-30.mxd

RAMBOLL	**Ethylbenzene Plume Map - December 2017** Vogel Paint Waste Site Maurice, Iowa	FIGURE **5**
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Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure6_PlumeMap_Xylene_2018-07-30.mxd

RAMBOLL	**Xylene Plume Map - December 2017** Vogel Paint Waste Site Maurice, Iowa	FIGURE **6**
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Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure7_GroundwaterElevation_2018-07-27.mxd

RAMBOLL	**Groundwater Elevation Map - November 2017** Vogel Paint Waste Site Maurice, Iowa	FIGURE **7**
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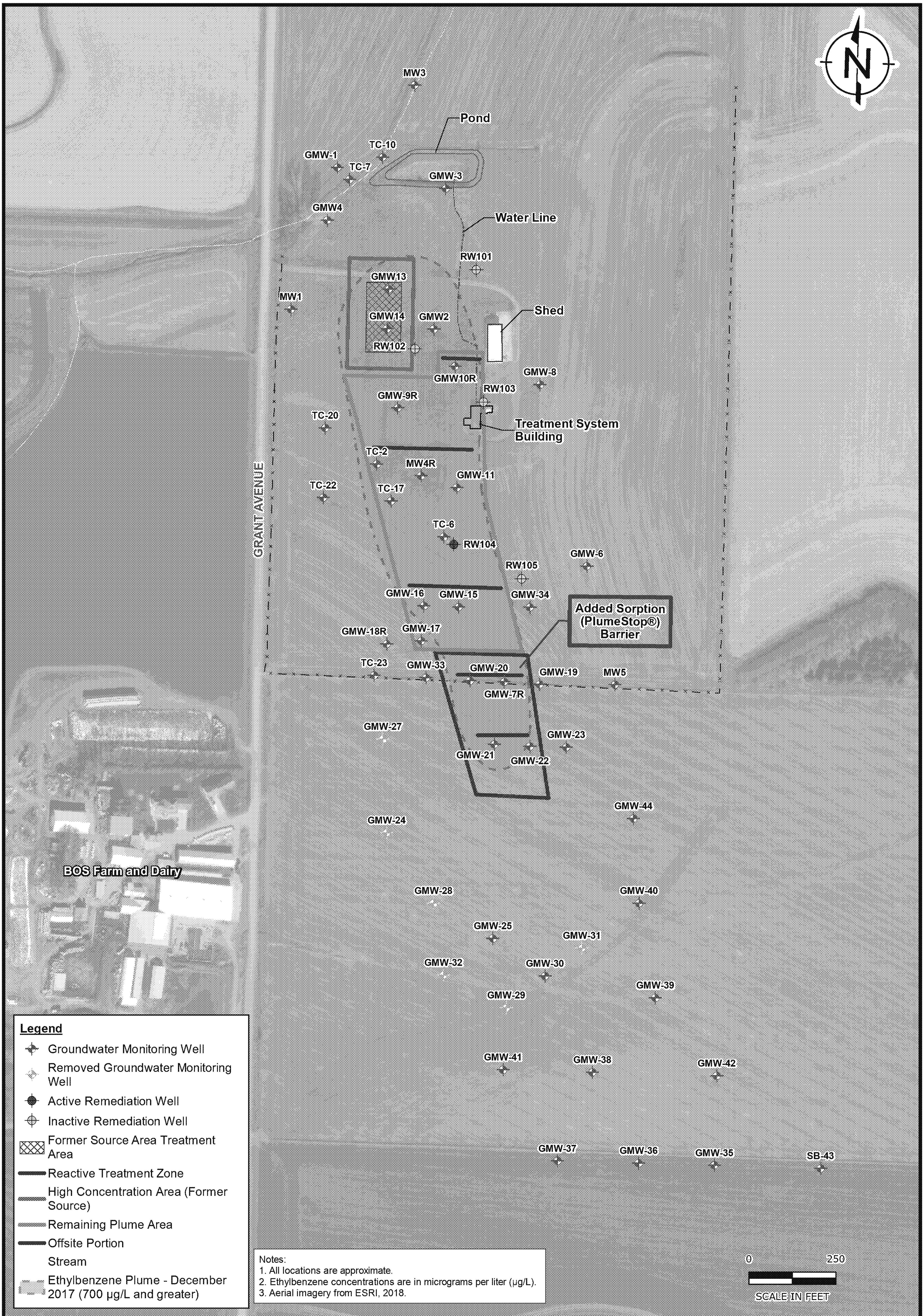
Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure8_RemedialLayout_2018-07-30.mxd



RAMBOLL

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Remedial Layout
Vogel Paint Waste Site
Maurice, Iowa

FIGURE
8

PROJECT: 1690001847-004

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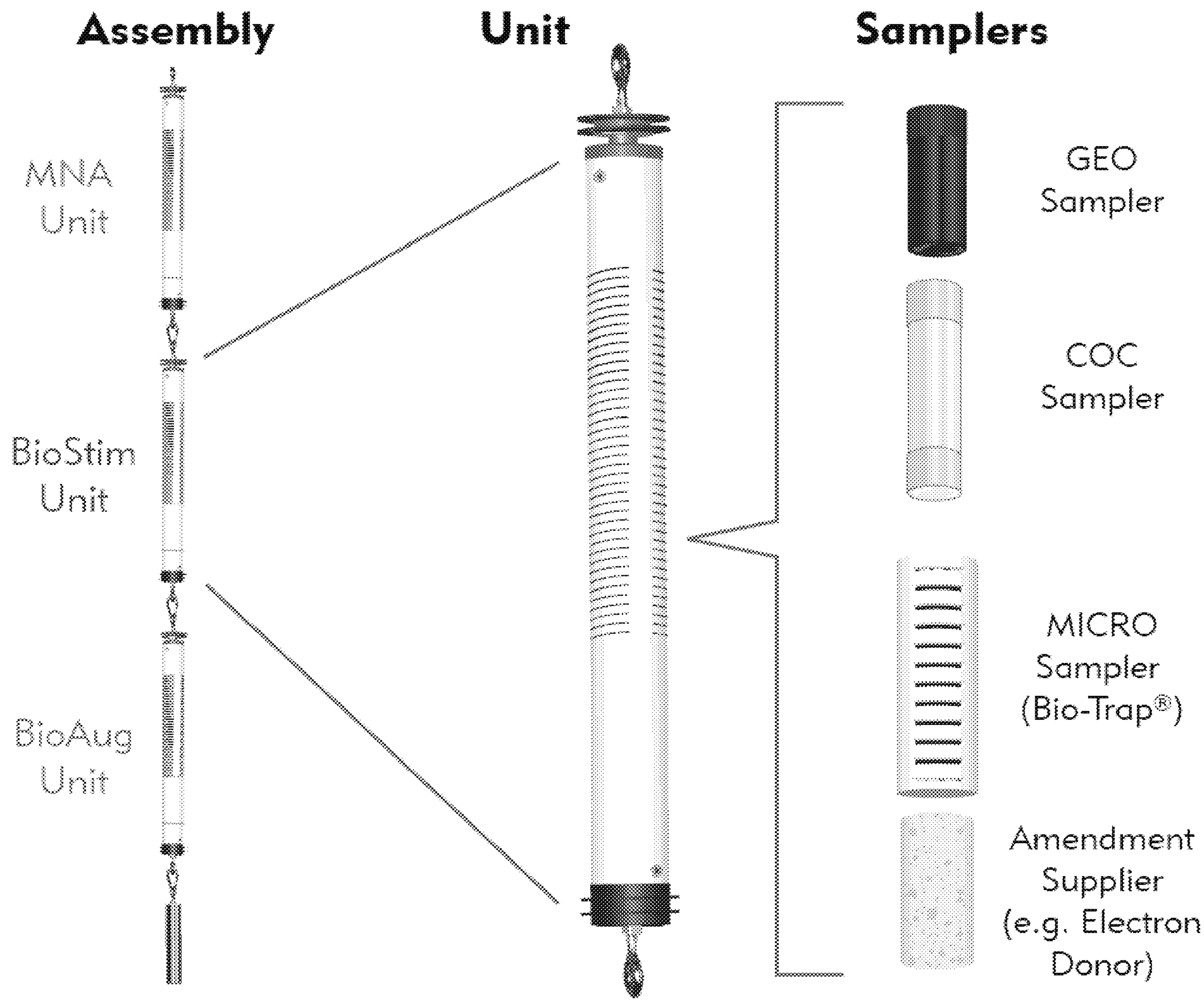

*Schematic not to scale.

C:\Users\JDKing\Documents\JDKING_ArcGIS Working\GIS Requests\Vogel Paint\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure9_Bio-Trap_Schematic_2018-07-26.mxd

RAMBOLL

Bio-Trap Schematic
Vogel Paint Waste Site
Maurice, Iowa

FIGURE
9

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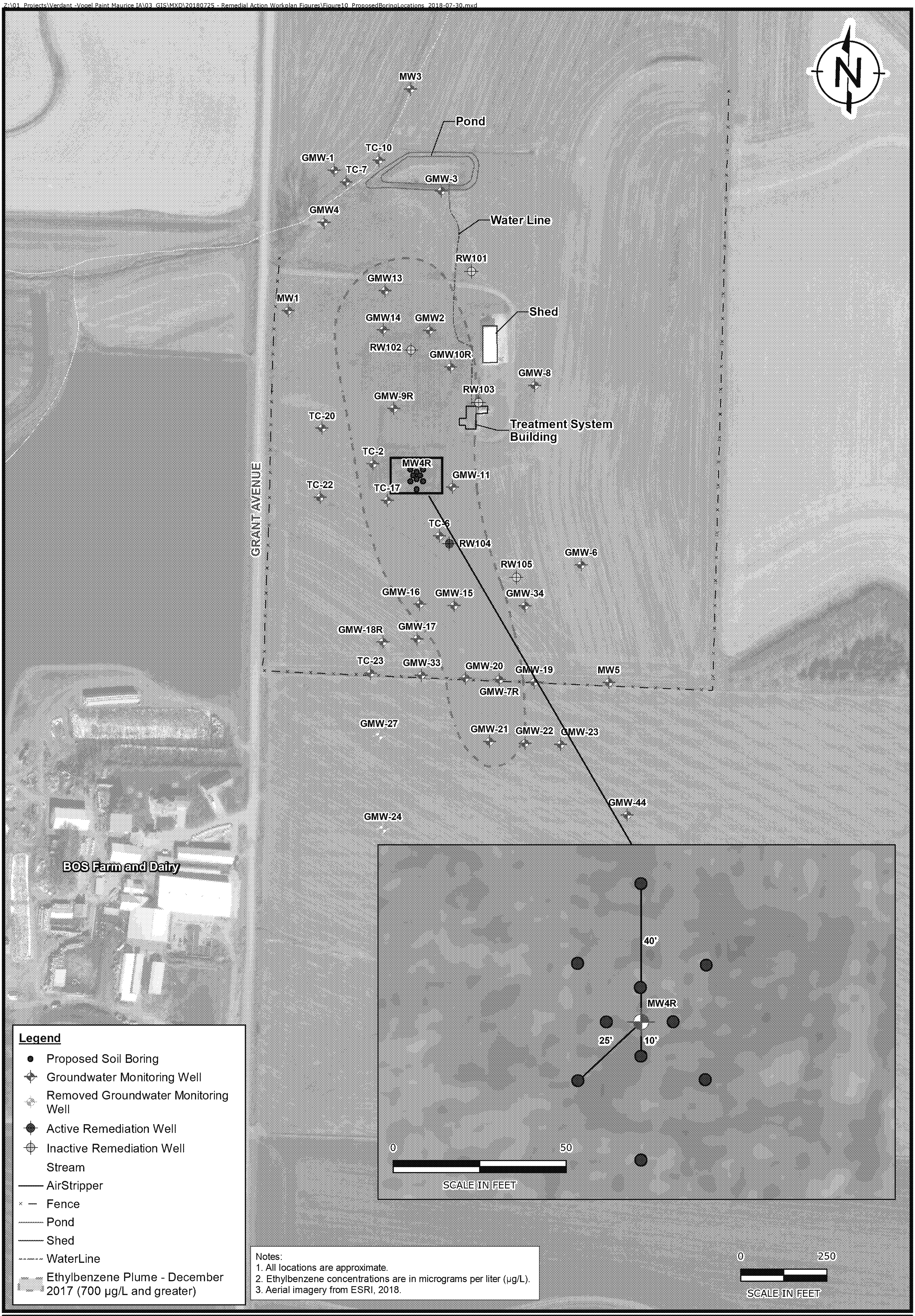
Z:\01_Projects\Verdant -Vogel Paint Maurice IA\03_GIS\MXD\20180725 - Remedial Action Workplan Figures\Figure10_ProposedBoringLocations_2018-07-30.mxd



RAMBOLL

Proposed Boring Locations Map
Vogel Paint Waste Site
Maurice, Iowa

FIGURE
10

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